PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B01D 53/22 | A1

(11) International Publication Number: WO 99/38602

(43) International Publication Date: 5 August 1999 (05.08.99)

(21) International Application Number: PCT/US99/02435

(22) International Filing Date: 29 January 1999 (29.01.99)

(30) Priority Data:
09/016,139 30 January 1998 (30.01.98) US

(71)(72) Applicant and Inventor: CHAHAL, Kam [US/US]; P.O. Box 4088, Breckenridge, CO 80424 (US).

(74) Agent: BRADDOCK, Chris; Suite 3205, 1999 Broadway, Denver, CO 80202 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: ATMOSPHERIC OXYGEN ENRICHING DEVICE

(57) Abstract

An oxygen enriching apparatus has an oxygen enriching module, a motor, a blower, a hollow cylinder which contains a porous center tube, a filter, an exhaust port and a vacuum port. The apparatus simultaneously pushes and pulls atmospheric air through the oxygen enriching module to produce oxygen enriched air. The filter has a semi-permeable membrane positioned about the porous center tube and between two perforated polyester liners and a vinyl liner positioned on the outside of the filter. A vacuum is applied between the vinyl lining and the outermost polyester lining to draw the oxygen enriched air out of the module.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

ATMOSPHERIC OXYGEN ENRICHING DEVICE

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates to a new process and device for producing enriched oxygen, and more particularly to a new process and device utilizing membrane separation for producing enriched oxygen from atmospheric air.

2. DISCUSSION OF THE PRIOR ART

Oxygen enriching devices have been used to treat patients suffering respiratory ailments, such as emphysema and to aid individuals in high altitude and/or low oxygen environments. The two most popular methods of producing oxygen enriched air uses either the absorption separation method or the membrane separation method. The absorption separation method uses a nitrogen fixing material, such as zeolite to increase the density of oxygen delivered to the patient. In this method a continuous flow of atmospheric air is passed over a nitrogen fixing compound to increase the density of oxygen in the air delivered to the user. The membrane separation method uses a permeable membrane which allows oxygen to diffuse through the membrane at a higher rate than the nitrogen. In this method a continuous flow of air is passed through a permeable membrane which separates the air into one region of oxygen enriched air and one region of oxygen depleted air. The oxygen enriched air is then delivered to the patient either through a mask or a nasal tube, while the oxygen depleted air is exhausted.

There have been several patents issued to oxygen enriching devices. Most notably are Patent Nos. 4,491,459 to Pinkerton; 4,971,609 to Pawlos; 5,531,807 to McCombs; 4,174,955

to Blackmer et. al.; 4,789,388 to Nishibata et. al.; 3,930,814 to Gessner; 5,296,110 to Tabatabaie-Raissi; 5,158,584 to Tamura; and 5,129,924 to Schultz.

The device to Pinkerton describes an oxygen enriching system which uses a sieve bed of zeolite material to trap the nitrogen in atmospheric air. This device discloses a two step method, which first passes the atmospheric air through an inorganic silicate material to filter out the larger particles, and then passing this filtered atmospheric air through a zeolite material to entrap the free nitrogen. The device to Pawlos uses zeolite material in conjunction with a venturi tube. The atmospheric air is passed through a venturi tube creating a pressure gradient and thereby enhancing the separation of the gases before being passed through a zeolite material. The device to McCombs discloses an apparatus and method for providing airline passengers with oxygen enriched air. This device uses a pressure swing absorption unit, which passes the ambient air over at least one bed of a molecular sieve material such as zeolite. These absorption separation methods all suffer from one or more of the following disadvantages. First, the zeolite only has a limited capacity for trapped nitrogen, therefore the zeolite must be purged of the trapped nitrogen. During this purge cycle, no oxygen enriched air can be produced. Furthermore the noise created by the purge cycle is generally loud and painful to the patient. Additionally, these systems deliver the oxygen enriched air to the patient using a nasal cannila, thereby restricting the freedom and movement of the patient, and these systems weigh between 60-80 pounds.

The device to Blackmer et. al. uses a permeable membrane in conjunction with a vacuum to increase diffusion of the atmospheric oxygen through the membrane. This device uses a fan to blow atmospheric air over a selectively permeable membrane to enrich the atmospheric oxygen to 40%, and then delivers this enriched oxygen directly to the patients

nose. The major distinction between the invention at hand and the device to Blackmer et al. is that the invention at hand utilizes a oxygen enriching cartridge which uses a unique design to maximize the surface area of the semi-permeable membrane while shrinking the overall size and weight of the oxygen enriching device. Additionally, the invention at hand is able to create a high oxygen environment in a room, thereby delivering a high oxygen concentration directly to the patient with out using a nasal delivery system. Furthermore, the device to Blackmer et al., because of the nasal delivery system, must deliver 6 to 12 liters of enriched oxygen per minute to the patient's nose in order to obtain the desired amount of oxygen in the lung alveoli. This high flow rate is extremely difficult for the patient to tolerate and irritating to the nasal mucousal membrane.

The device to Gessner uses an array of semi-permeable membranes in combination with high pressure to force atmospheric air throughout the semi-permeable membranes to create enriched oxygen. This device also measures the pressure differentials between the two arrays of semi-permeable membrane to discern if a leak exists. Again the major distinctions from the device to Gessner and the invention at hand is that the invention at hand is configured to allow a greater surface area for the gas exchange while allowing the device to be substantially smaller in weight and size. Additionally, the device to Gessner delivers the enriched oxygen to the patient by using a nasal delivery system, which requires the flow rate of the enriched oxygen to the patient to be substantial. The invention at hand uses low pressure in combination with a vacuum to create a larger pressure differential through the semi-permeable membrane. This larger pressure gradient allows this invention to increase the concentration of oxygen in a room instead delivering the enriched oxygen using a nasal delivery system.

The device to Nishibata et al. discloses a method and apparatus for reducing the noise levels in both absorption separation and membrane separation oxygen enriching devices. The device to Tabatabaie-Raissi uses an electrolytic system to enrich atmospheric air with oxygen. The device to Tamura discloses a small and lightweight oxygen enriching module which forces atmospheric air through bundles of hollow core fibers to create separation of oxygen from atmospheric air. This device however, is size dependent and is not able to separate the particulate, bacterial and viral impurities inherent in atmospheric air. The device to Schultz discloses an supplemental oxygen ventilator which forces atmospheric air through a duct constructed of a material which is permeable to nitrogen and impermeable to oxygen, such as unglazed porcelain.

SUMMARY OF THE INVENTION

The basic principle of this invention is selective separation of nitrogen and oxygen. Normally, 79% of the atmospheric air is nitrogen and approximately 21% is oxygen. This device by selectively removing the nitrogen from the air is able to deliver oxygen enriched air with an oxygen concentration of up to 50% oxygen. By delivering a higher concentration of oxygen to the patient, a higher partial pressure of oxygen is created within the lungs, thus allowing more efficient transfer of oxygen molecules to the hemoglobin, and thereby allowing a patient to lead a more normal life.

The underlying purpose of oxygen therapy is to create a steady oxygen availability to the vital organs. However if the oxygen concentration delivered to the patient becomes to high, there is a significant risk of carbon dioxide retention, and therefore carbon dioxide narcosis and depression of the respiratory center. The benefits of oxygen therapy have been proven to outweigh the negative effects. Namely, the survival statistics with home oxygen

therapy indicates a decrease in the frequency of hospitalizations and an improvement in the overall quality of life in patients with respiratory disease. Therefore, if steady oxygen levels could be attained and maintained, the patient's quality of life would substantially improve. Conventional oxygen enriching devices have been able to produce oxygen enriched air, however the oxygen concentration was not maintainable and has fluctuated between 21-30%, creating a greater risk of many undesirable physiological reactions such as carbon dioxide narcosis. The invention at hand is able to provide a maintainable, precise degree of oxygen enriched air which allows the blood oxygen levels to remain constant.

Additionally, conventional oxygen enriching devices have been required to deliver the oxygen enriched air to the patient via a nasal cannular or a face mask. To create the necessary partial pressures in the lung for efficient gas transfer, the nasal cannular delivery would require that the oxygen enriched air be supplied to the patient in the range of 6-12 liters per minute. To create the necessary partial pressures in lung for efficient gas transfer, the face mask delivery system would require that oxygen enriched air be supplied to the patient at 10-15 liters per minute. Theses very high flow rate are extremely difficult to tolerate and irritating to the nasal mucousal membranes. Additionally, these delivery methods will impede the patients freedom to move around and overall quality of life.

Because this invention utilizes a semi-permeable membrane, it is able to successfully remove all bacteria, viruses, pollens and noxious gases from the air before the being delivered to the patient. Additionally, because of this invention's light weight and portability, this device can also be used in high altitude activities such as mountaineering to prevent altitude sickness. The invention consists of an oxygen enriching module, a pump, a motor and a blower. The oxygen enriching module is a hollow cylinder which contains a porous center tube, a vacuum

port and an exhaust port. The porous center tube is completely surrounded throughout the length of the module with a filter. This filter consists of a perforated polyester lining directly adjacent to the center tube, a semi-permeable membrane which is separated from the perforated polyester lining by a small gap, a second perforated polyester lining separated from the semi-permeable membrane by a small gap and a vinyl lining separated from the second perforated polyester lining by a small gap. The filter encircles the porous center tube in increasing spirals, and throughout the entire length of the center tube is the filter. An exhaust port and a vacuum port are located on the outer casing of the oxygen enriching module.

The invention works by applying positive pressure to the intake of the center tube and simultaneously applying vacuum to the vacuum port, thereby forcing atmospheric air through the module. Because oxygen will permeate through the membrane at a faster rate than the nitrogen, oxygen will take the straightest path to the high oxygen port, while the nitrogen will be forced to spiral through the module to the exhaust port. A vacuum is applied between the vinyl and the second perforated polyester lining to draw the enriched oxygen out of the module for delivery to the patient, while the membrane acts as a barrier and prevent nitrogen, noxious gases, pollens and other pollutants from being delivered. The spiral configuration allows for the surface areas of the filter to be greatly enhanced while the size and weight of the invention came be substantially reduced. A preferred embodiment of this invention is a portable oxygen enriching device with approximate dimensions of 6 inches tall, 4 inches wide by 2 inches thick. The portable device weighs approximately 10 ounces and will be able to operate on a rechargeable battery. The oxygen enriched air will be delivered to the patient by using a nasal cannila. However, because of this inventions lightweight and portability, it may

also be used in outdoor activities such as mountain climbing and skiing to prevent altitude sickness.

A second preferred embodiment of the invention is a stationary oxygen enriching device which will weigh approximately 16 pounds. Because of the efficiency of the oxygen enriching module, this device will be able to create and precisely maintain an enriched oxygen environment ranging between 21% to 50% oxygen in a room 15 foot by 15 foot. Using this embodiment, the patient will have no need to have the enriched oxygen delivered by nasal cannula, but will be able to breathe on their own. Both these anticipated embodiments of this invention will be nearly silent and be able to filter out bacterial, viral, pollens and other pollutants from the atmospheric air before the enriched oxygen is delivered to the patient. The value of this environmental cleaning of the air will be of particular importance in operating rooms, burn centers, and intensive care units where dangerous infections may be spread through the air.

Therefore it is a primary object of this invention to provide a new lightweight, and portable oxygen enriching device. Another object of this invention is to provide an oxygen enriching device that can precisely provide a specified concentration of oxygen. A third object of the invention is to provide an oxygen enriching device which will provide a maintainable concentration of oxygen. A fourth object of the present invention is to provide an oxygen enriching device which can successfully remove bacteria, viruses, pollens and noxious gases before delivering the oxygen enriched air to the patient. A further object of this invention is to provide an oxygen enriching device that can run silently and continuously with no need for a purge cycle. Yet another object of the invention is to provide an oxygen enriching device

which is portable yet affordable to use. Finally, it is a primary object of the invention to deliver oxygen enriched air to the patient without using a nasal cannular or face mask.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate the complete preferred embodiments of the present invention according to the best modes presently devised for practical application of the principles thereof, and in which:

FIG. 1 is a top view of the oxygen enriching module.

FIG. 2 is a schematic of a device which uses the invention.

FIG. 3 is a cross sectional view of the oxygen enriching module.

FIG. 4 is a side view of the oxygen enriching module.

FIG. 5 is a zoom view of the filter.

FIG. 6 is a cross sectional view of the filter.

DETAILED DESCRIPTION OF THE INVENTION

In the drawings like reference numerals throughout the various figures refer to like elements. Fig. 1 is a top view of the Oxygen Enriching Module 10 having a Center Tube 12 an Exhaust Port 14 a Vacuum Port 16 a plurality of Holes 18 located in the Center Tube 12 and a Air Intake 13. Fig. 2 is a schematic of a device which uses the invention and shows the Oxygen Enriching Module 10 the Center Tube 12 the Air Intake 13 the Exhaust Port 14 the Vacuum Port 16 the End Seal 20 the Filter 22 the Blower 40 the High Oxygen Input 42 the Blower Power Input 44 the Motor 46 the Pump Power Input 48 the Pump 50 the Atmospheric Input 51 Tubing 52 the Positive Pressure Valve 54 and the Patient Valve 56.

Fig. 3 is a cross-sectional view of the Oxygen Enriching Module **10**, and shows the Module Wall **11** Center Tube **12**, Holes **18** located in the Center Tube **12** the Exhaust Port **14** the Vacuum Port **16** the Filter **22** comprising of a First Gap **24** a First Polyester Lining **26** a Second Gap **28** a Semi-Permeable Membrane **30** a Third Gap **32** a Second Polyester Lining **34** a Fourth Gap **36** and a Vinyl Lining **38**. Fig. **4** is a side view of the Oxygen Enriching Module **10** and shows the Module Wall **11** Center Tube **12** the Air Intake **13** the Exhaust Port **14** the Vacuum Port **16** a plurality of Holes **18** located in the Center Tube **12** the End Seal **20** and Filter **22**. Fig. **5**. is a zoom view of the Filter **22** and shows the Center Tube **12** a plurality of Holes **18** located in the Center Tube **12** a First Gap **24** a First Polyester Lining **26** a Second Gap **28** a Semi-Permeable Membrane **30** a Third Gap **32** a Second Polyester Lining **34** a Fourth Gap **36** and a Vinyl Lining **38**. Fig. **6** is a zoom view of the Filter **22** and shows a First Polyester Lining **26** a Second Gap **28** a Semi-Permeable Membrane **30** a Third Gap **32** a Second Polyester Lining **34** a Fourth Gap **36** and a Vinyl Lining **38**.

The invention uses a push pull method and works by the Motor **46** simultaneously powering the Blower **40** and the Pump **50**. The Pump **50** draws atmospheric air into the Atmospheric Input **51** and pushes this air at greater than ambient air pressure through the Tubing **52** and into the Air Intake **13** of the Center Tube **12**. Simultaneously the Blower **40** is creating a vacuum at the Vacuum Port **16**, thereby creating a pressure gradient between the Air Intake **13** and the Vacuum Port **16**.

This pressure gradient forces the air through the Holes **18** in the Center Tube **12** and subsequently through Holes **18** in the Center Tube **12**, the First Gap **24** the First Polyester Lining **26** the Second Gap **28** the Semi-Permeable Membrane **30** the Third Gap **32** the Second Polyester Lining **34** the Fourth Gap **36** and the Vinyl Lining **38**. The First Polyester Lining **26**,

the Semi-Permeable Membrane **30** the Second Polyester Lining **34** and the Vinyl Lining **38** are all attached to the Center Tube **12** and completely encircle, spiral out and run the entire length of the Center Tube **12** and are eventually fixed to the Module Wall **11** of the Oxygen Enriching Module **10**. The Vacuum Port **16** is positioned on the Module Wall **11**, between the Vinyl Lining **38** and the Second Polyester Lining **34**. The Exhaust Port **14** is positioned on the Module Wall **11** between the First Polyester Lining **26** and the Semi-Permeable Membrane **30**. For best results, the First Polyester Lining **26** and the Second Polyester Lining **34** should be perforated.

The spiral configuration of the filter will allow for more efficient gas separation while greatly reducing the size and weight of the oxygen enriching device. The vacuum pulls oxygen enriched air from the Fourth Gap **36**, while the pollens, bacteria, viruses and noxious gases are pushed out the exhaust Port **14**. Because oxygen diffuses at a greater rate through the Semi-Permeable Membrane **30** than nitrogen, oxygen enriched air will be produced and drawn towards the Vacuum Port **16**. Because bacteria, viruses, pollens, noxious gases and other pollutants will be unable to travel through the Semi-Permeable Membrane **30**, the oxygen enriched air produced will be cleaner and pollutant free. The nitrogen and other pollutants, because of the Semi-Permeable Membrane **30** and the pressure gradient will be forced to traverse the Oxygen Enriching Module **10** in an elongated spiral path before finally being exhausted out the Exhaust Port **14**. From the Vacuum Port **16**, the oxygen enriched air will travel to the Blower **24** via the Tubing **36** before finally being delivered to the patient. The Patient Valve **40** located between the Blower **24** and the patient is used to control the flow rate of the oxygen enriched air. Also the Positive Pressure Valve **38** located between the

Pump 34 and the Air Intake 13 is used to control the degree of positive pressure applied to the Air Intake 13.

It will now be understood that what has been disclosed herein includes a new oxygen enriching device which is particularly advantageous for those suffering from lung disease or for those wishing to participate in high altitude/ low oxygen activities. Those having skill in the art to which the present invention relates will now, as a result of the teaching herein, perceive various modifications and additions which may be made to the invention. Accordingly, all such modifications and additions are deemed to be within the scope of the invention which is to be limited only by the claims.

What is claimed is:

1. An oxygen enriching module for producing oxygen enriched air from atmospheric air, which uses a filter designed to allow oxygen to diffuse through the filter at a faster rate than nitrogen, consisting of:

a. an oxygen enriching module having a module wall, center tube, an exhaust port, a vacuum port and a filter;

b. said center tube having an air intake on one end, being sealed on the opposite end and having means to allow atmospheric air to leak into said filter;

c. said filter being comprised of a first gap, a first polyester lining, a second gap, a semi-permeable membrane, a third gap, a second polyester lining, a fourth gap and a vinyl lining;

d. means for attaching said filter to said center tube and means to attach said filter to said module wall.

2. An oxygen enriching module for producing oxygen enriched air from atmospheric air, which uses a filter designed to allow oxygen to diffuse through the filter at a faster rate than nitrogen of claim 1 wherein said filter substantially encircles and runs the full length of said center tube and spirals outward towards said module wall.

3. An oxygen enriching module for producing oxygen enriched air from atmospheric air, which uses a filter designed to allow oxygen to diffuse through the filter at a faster rate than nitrogen of claim 1 wherein said vacuum port is positioned between said vinyl lining and said second polyester lining, and wherein said exhaust port is positioned bewteen said first polyester lining and said semi-permeable membrane.

4. An oxygen enriching module for producing oxygen enriched air from atmospheric air, which uses a filter designed to allow oxygen to diffuse through the filter at a faster rate than nitrogen of claim 1 and 3 wherein positive pressure is used to push air into said air intake at higher than ambient pressure.

5. An oxygen enriching module for producing oxygen enriched air from atmospheric air, which uses a filter designed to allow oxygen to diffuse through the filter at a faster rate than nitrogen of claim 1 and 3 wherein a vacuum is used to pull oxygen enriched air from said vacuum port.

6. An oxygen enriching module for producing oxygen enriched air from atmospheric air, which uses a filter designed to allow oxygen to diffuse through the filter at a faster rate than nitrogen of claim 1 and 3 wherein positive pressure is used to push air into said air intake at higher than ambient pressure and a vacuum is used to pull oxygen enriched air from said vacuum port.

7. An oxygen enriching module for producing oxygen enriched air from atmospheric air, which uses a filter designed to allow oxygen to diffuse through the filter at a faster rate than nitrogen of claim 1 wherein the dimension of said first gap is zero.

8. An oxygen enriching module for producing oxygen enriched air from atmospheric air, which uses a filter designed to allow oxygen to diffuse through the filter at a faster rate than nitrogen of claim 1 wherein the dimension of said second gap is zero.

9. An oxygen enriching module for producing oxygen enriched air from atmospheric air, which uses a filter designed to allow oxygen to diffuse through the filter at a faster rate than nitrogen of claim 1 wherein the dimension of said third gap is zero.

10. An oxygen enriching module for producing oxygen enriched air from atmospheric air, which uses a filter designed to allow oxygen to diffuse through the filter at a faster rate than nitrogen of claim 1 wherein the dimension of said first gap, said second gap and said third gap are all zero.

11. An oxygen enriching module for producing oxygen enriched air from atmospheric air, which uses a filter designed to allow oxygen to diffuse through the filter at a faster rate than nitrogen of claim 1 wherein said filter is able to prevent bacteria, viruses, pollens, noxious gases from diffusing through said filter.

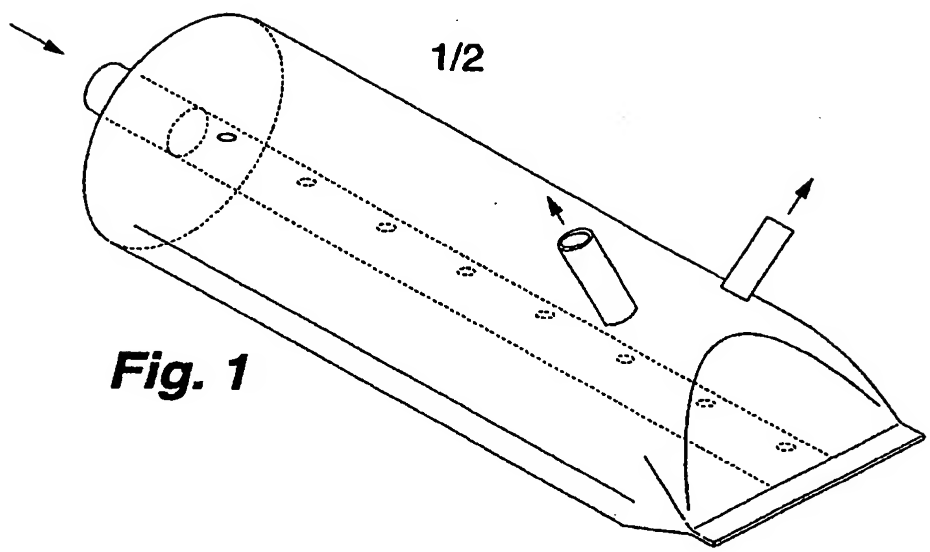
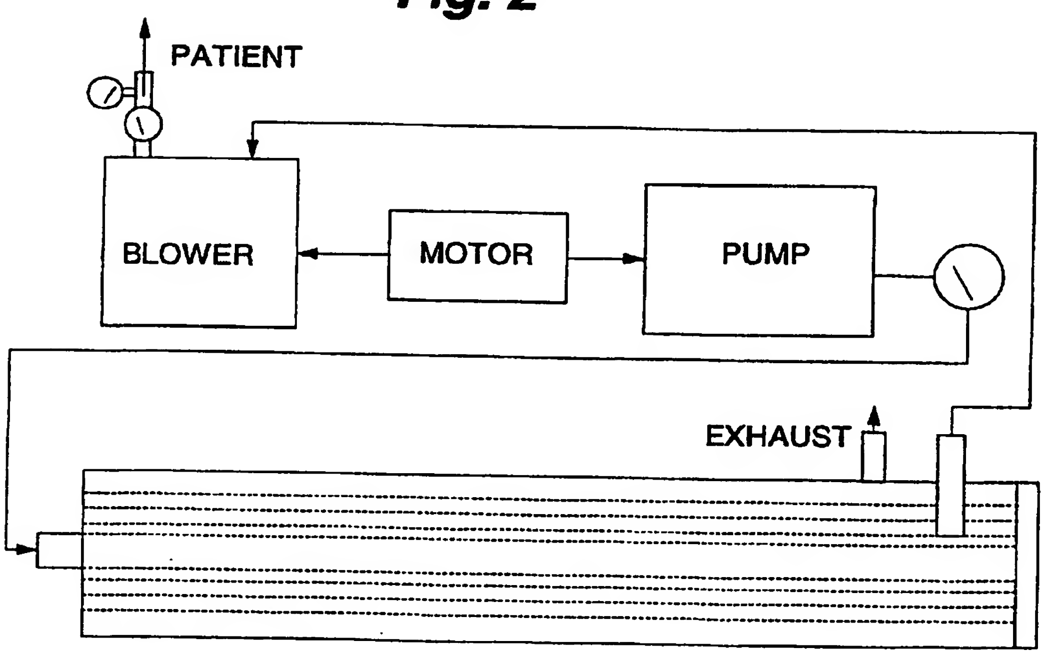


Fig. 1

Fig. 2



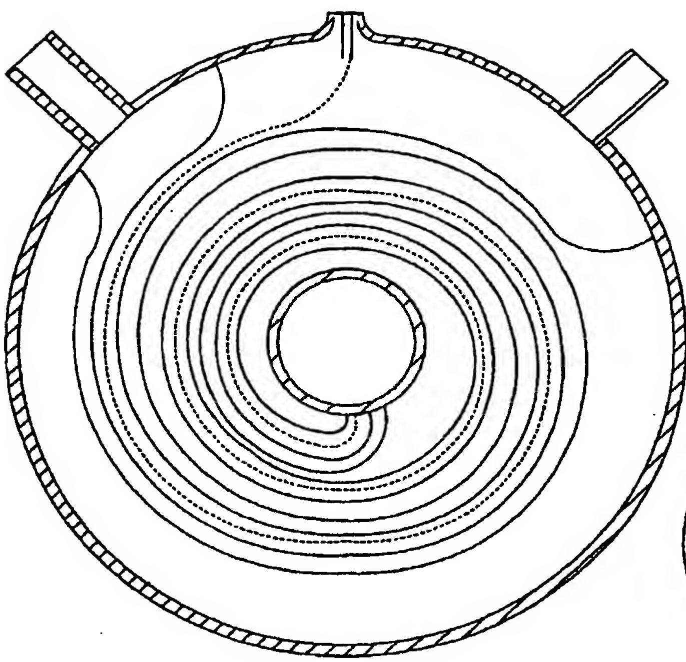
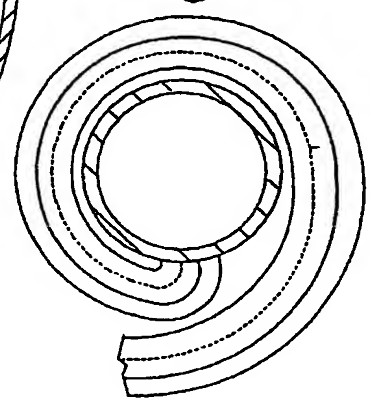


Fig. 3

Fig. 5



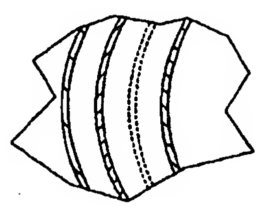


Fig. 6

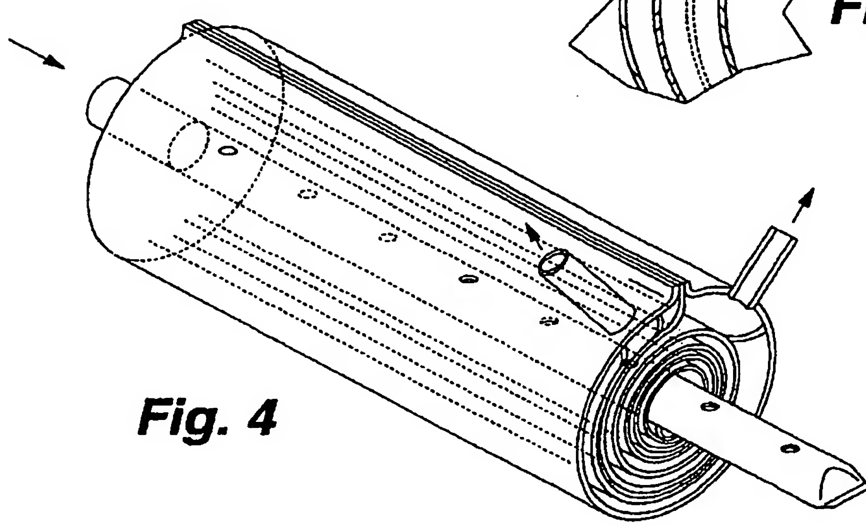


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/02435

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :B01D 53/22
US CL :96/10, 12
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 95/45, 54; 96/4, 7-14; 210/321.76, 321.85

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3,397,790 A (NEWBY et al) 20 August 1968 (20-08-68).	1-11
A	US 3,872,014 A (SCHELL) 18 March 1975 (18-03-75).	1-11
A	US 3,930,814 A (GESSNER) 06 January 1976 (06-01-76).	1-11
A	US 3,976,451 A (BLACKMER et al) 24 August 1976 (24-08-76).	1-11
A	US 4,553,988 A (SHIMIZU et al) 19 November 1985 (19-11-85).	1-11
A	US 4,789,388 A (NISHIBATA et al) 06 December 1988 (06-12-88).	1-11

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
02 JUNE 1999

Date of mailing of the international search report
15 JUN 1999

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
ROBERT H. SPITZER
Telephone No. (703) 308-0651

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/02435

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,158,584 A (TAMURA) 27 October 1992 (27-10-92).	1-11
A	US 5,711,882 A (HOFMANN et al) 27 January 1998 (27-01-98).	1-11
A	JP 62-001,405 A (TORAY IND INC) 07 January 1987 (07-01-87).	1-11
A	JP 03-028,104 A (TORAY IND INC) 06 February 1991 (06-02-91).	1-11